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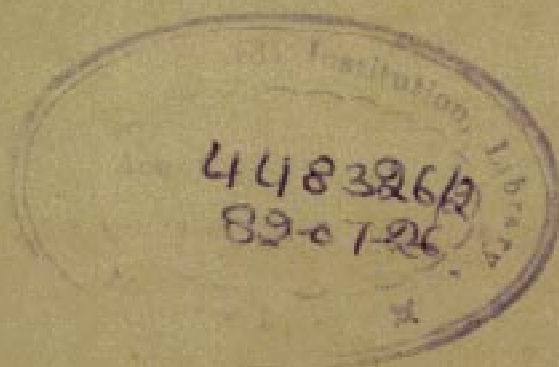
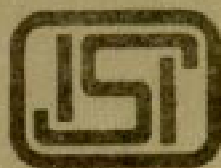
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Indian Standard

METHOD OF TEST FOR SMOOTHNESS/ROUGHNESS OF PAPER

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Indian Standard

METHOD OF TEST FOR SMOOTHNESS/ROUGHNESS OF PAPER

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Indian Standard

METHOD OF TEST FOR SMOOTHNESS/ROUGHNESS OF PAPER

0. F O R E W O R D

0.1 This Indian Standard was adopted by the Indian Standards Institution on 15 September 1981, after the draft finalized by the Paper and Its Products (Excluding Packaging Materials) Sectional Committee had been approved by the Chemical Division Council.

0.2 It is not possible to recommend a single method for measuring the smoothness or roughness of a paper, and there is no exact correlation among the various methods used for determining these properties. However, several instruments of the constant pressure air-flow type have been designed to obtain a numerical value indicative of the smoothness or roughness of paper or board. But as results of determinations obtained with different instruments are not necessarily convertible, it is necessary to refer to the results of this test in terms of the specific type of instrument used, such as Bendtsen roughness and Sheffield roughness instrument.

0.3 Although different methods of test have been given in this standard, as far as possible, Gurley instrument values should be indicated as this is the most widely used instrument.

0.4 While preparing this standard, considerable assistance has been derived from ISO 2494-1974 Paper and board — Recommended procedure for the determination of roughness — Constant-pressure air-flow method.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS: 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard prescribes the method of test for smoothness/roughness of paper and board.

*Rules for rounding off numerical values (*revised*).

2. TERMINOLOGY

2.1 For the purpose of this standard, the following definition in addition to those given in IS:4661-1968* shall apply.

2.1.1 Roughness — The measure of the extent to which the surface of the paper deviates from a plane and involves the depth, width and number of departures from the plane.

3. BENDTSEN AND SHEFFIELD INSTRUMENTS

3.1 Principle — The test piece is pressed under a definite pressure by one or two annular metal lands against a smooth, plane, hard surface. Air is supplied at a constant pressure to the centre of the annular land or between the lands, and the air flow passing between the annular land and the surface of the paper is measured. The instrument reading is greater with rougher papers and boards and, for this reason, the values are known as a measure of roughness.

3.2 Apparatus — The apparatus shall consist of the following major components:

3.2.1 Means of supplying clean conditioned air to the measuring head at a relative humidity of 65 ± 2 percent at a temperature of $27 \pm 2^\circ\text{C}$ and at a constant pressure of:

- a) 1.47 ± 0.02 kPa (150 ± 2 mm H₂O) in the Bendtsen-type instrument; and
- b) 10.3 ± 0.2 kPa in the Sheffield-type instrument.

NOTE — This may conveniently be done by passing the normal conditioned air in a laboratory through a small compressor. The compressed air should be cooled to room temperature and the pressure stabilized by means of a large capacity reservoir (about 10 litres is a suitable size).

The constant pressure is normally maintained by means of a manostat, or regulator, which is an integral part of the instrument.

3.2.2 Device to measure the air flow rate accurate to ± 5 percent.

NOTE — The lowest flow rate normally measurable is 5 ml/min. However the required accuracy cannot normally be obtained with a flow rate of less than 10 ml/min. It is convenient to use variable area flowmeters of overlapping ranges. The accuracy requirement then applies to the flowmeter in use.

3.2.3 Measuring Head — It shall be constructed of hard steel, on the under surface of which one or two optically flat annular metal lands protrude far enough so that only the lands contact the test piece. The lands shall be made of or finished with a corrosion-resistant material (for

*Glossary of terms used in paper trade and industry.

example, stainless steel or chromium plating). In the Bendtsen-type instrument, the air supply is led to the annular groove between concentric lands. The air then escapes across the surface of the test piece under the land(s). With the air supply off the pressure of the land(s) should be 170 ± 5 kPa, obtained as follows:

- a) in the Bendtsen-type instrument, with a head having a mass of 267 ± 2 g and an annulus of 0.150 ± 0.002 mm width and 31.75 ± 0.25 mm internal diameter.
- b) in the Sheffield-type instrument, with a head having a mass of 1640 ± 2 g and two concentric lands each of 0.380 ± 0.005 mm in width, the two having a tolerance and total area 97 ± 3 mm²

With the air supply on, this pressure is reduced by buoyancy, only slightly on the Sheffield instrument, but to 98 kPa on the Bendtsen instrument.

3.2.4 Flat Plate Glass Surface — free from flaws, on which to rest the test piece.

NOTE — The flatness of the glass should be sufficient to give no detectable movement of the flowmeter float over the working area.

3.2.5 Heavy metal annulus or other suitably shaped weight, suitable for keeping the test piece flat around the measuring head.

NOTE — The components may conveniently be connected with rubber tubing. Care shall be taken to ensure that the rubber tubing does not affect the pressure exerted by the measuring head. For the connections between instrument and measuring head, thin walled rubber tubing of 5 mm inside diameter and elsewhere tubing of 7 mm inside diameter have been found suitable.

3.3 Calibration

3.3.1 Leakage — Check the instrument frequently for leakage. First place a piece of smooth, soft, impermeable rubber on the plate glass and place the measuring head on it. With the instrument working and the lowest range flowmeter connected, no rise of the flowmeter float should be detectable (other than a slight jump when the air supply is switched on). If this is not so, there is a leak between the flowmeter and the measuring head and the connecting tubing and joints should be checked. Minor leaks on the high pressure side of the flowmeter do not matter.

3.3.2 Measuring Head — If the instrument is leakproof, check the flatness of the annular land(s) on the measuring head. Clean the flat plate glass surface and place the measuring head on it. Switch on the instrument and connect the lowest range flowmeter; it should be possible to find a position on the glass plate where there is no rise of the flowmeter float. If no such position can be found, clean the land(s) with a suitable solvent.

If the instrument is still not leakproof examine the annular land(s) for visible defects. This may be done using a magnification of X 20 to X 30, for instance, with a stereoscopic microscope. If any major change can be seen, the head should be discarded, or ground and polished by a competent person. Minor defects may be eliminated by placing the head on a plate glass square upon which has been placed some fine polishing powder in a suitable medium, for example, jewellers rouge, crocus powder or metal polish. The defects are polished out by holding the head lightly but firmly flat on the plate and imparting a circular motion to it. The head shall be lifted from time to time and the operation continued until the defect has disappeared.

NOTE — Care should be taken to ensure that the polishing does not change the area of the land (s).

3.3.3 Rate of Air-Flow — Use capillary gauges or standardized orifices to check the flowmeters.

NOTE — Further specification of the checking methods for air pressure and flow rates is not considered justified because of the limited overall accuracy of the method and the limited overall precision resulting from the high variability of the roughness of paper.

3.4 Test Specimen — Select specimens and take at least ten test pieces, each measuring not less than 100×100 mm. It is essential to use a fresh test area for each determination. There shall be no folds, creases, visible cracks or other defects on the area to be tested and the test pieces shall not include any part of the sample that is less than 15 mm from the edge of the sheet or reel. If watermarks are present, this should be stated in the test report.

3.5 PROCEDURE

3.5.1 Condition the test specimens as prescribed in 5 of IS: 1060 (Part I)-1966*.

3.5.2 Level the instrument and place it on a surface free from vibration. Remove or raise the measuring head, place the test piece on the glass plate with the side to be tested uppermost. If the test piece does not lie flat, it is important to use the metal annulus. Turn on the compressed air supply and select the maximum flowmeter range.

NOTE — In the Bendtsen-type instrument, the air supply should be turned on before the manostat is placed on the spindle, and the manostat weight should be removed before the air supply is turned off. This prevents wear of the manostat and spindle caused by friction.

*Methods of sampling and test for paper and allied products, Part I (revised).

3.5.3 Gently place the measuring head on the test piece keeping the land(s) parallel to the test piece surface and being careful not to exert any pressure on it apart from the weight of the gauging head, as this may deform the paper excessively and lead to a falsely low value.

NOTE — The way in which the head is placed on the test piece is most important and has been shown to affect the results by as much as 20 percent. Great care should be taken to see that this is done properly.

3.5.4 Ensure that the connecting tube is correctly positioned.

3.5.5 If the flow rate is within the compass of a lower range meter, switch over to it. Note the reading indicated at the top of the float 5 seconds after the head is placed on the test piece (even if the flowmeter reading is still changing).

3.5.6 For subsequent readings, leave the instrument switched on and merely raise and place the head on other test pieces, until ten readings have been obtained. When possible, use the same flowmeter throughout a series of measurements.

4. GURLEY - HILL SPS INSTRUMENT

4.1 Apparatus

4.1.1 The apparatus shall consist of a pair of optically flat, circular clamping plates having an effective area of $64.516 \pm 0.322 \text{ mm}^2$. The upper plate shall be fixed to the outlet of an air tube, and the power plate shall be supported at its centre upon a round-headed pin and shall be arranged to clamp the paper sample under a pressure of approximately 21 kN/m^2 by means of an unweighted lever arm.

4.1.2 Air pressure for the test shall be provided by an inner cylinder having a closed top, which slides freely in an outer cylinder filled to a depth of approximately 127.0 millimetres with mineral oil (viscosity 65 ± 5 seconds Saybolt at 37.7°C). Air shall be conducted to the clamping plates through a tube extending above the surface of the oil within the inner cylinder.

4.1.3 The outer cylinder shall be approximately 254.0 millimetres in height and 82.5 millimetres in diameter. Four bars, each approximately 190.5 mm in length, 3.0 mm in width and 1.5 mm in thickness shall be mounted vertically and equidistantly on the inner surface of the outer cylinder to act as guide tracks for the movable cylinder.

4.1.4 The movable cylinder, shall be graduated in units of 50 ml, and shall have a total range of 350 ml. It shall be 254.0 mm in height and shall have an external diameter of 76.2 mm and an internal diameter of 73.7 mm. It shall weigh 567 ± 0.5 grams, producing an air pressure equal to 124.2 mm of water.

4.1.5 A support shall be provided on the outer cylinder to hold the inner cylinder in a raised position prior to making a test.

4.2 Calibration — Test the apparatus for air leakage by clamping the clamping plate in the normal manner after their contact surfaces have been thoroughly cleaned by a solvent. Release the inner cylinder so that it floats in the same manner as when making a test. The air leakage shall not exceed 60 ml in 5 hours.

NOTE — If a greater leakage occurs, tighten all joints and examine the clamping plate for scratches or dents. Any damaged instrument will not give true reading and should be repaired.

4.3 The test specimen shall be clean and free from abnormalities such as water marks, creases and wrinkles.

4.3.1 Each test specimen shall consists of 8 thicknesses of the sample, each not less than 5 cm square, arranged to so that all the felt and all the wire sides are respectively in contact with each other. A single sheet folded to give eight thicknesses may be used. In cases of extremely high or low smoothness, it may be convenient to use a greater or lesser number of thickness of paper of the test specimen.

4.4 Procedure

4.4.1 Condition the test specimens as prescribed in 5 of IS : 1060 (Part I)- 1966*.

4.4.2 Place the apparatus on a level surface. Insert the prepared specimen in the punch on the base of the apparatus, and punch a hole in the centre of the pad. Raise the inner cylinder until it rests on the support. Insert the punched specimen between the upper and lower clamping plates so that the hole is centred in the clamps. Adjust the lower plate until the lift produced by the lever arm is sufficient to clamp the sample securely. Lower the lever arm by means of the handle which actuates the lifting cam. The specimen is now clamped for test.

4.4.3 Gently lower the inner cylinder until it floats in the oil. When a steady downward movement has been reached, measure by a stop watch or an automatic timing attachment the number of seconds required for any two consecutive 50 ml intervals to pass the rim of the outer cylinder, or for greater or smaller volumes if the finish of the sample makes this advisable.

4.4.4 Take precautions to avoid subjecting the apparatus to vibration as this increases the rate of air displacement.

5. EXPRESSION OF RESULTS

5.1 Express the results as Bendtsen roughness in millilitres per minute or as Sheffield roughness in ('Sheffield unit'), separately for each side of the

*Methods of sampling and test for paper and allied products: Part I (revised).

paper or board. For Gurley-Hill SPS instrument, report the smoothness as the average time in second required for 50 ml of air to pass between the test surfaces of the test sample; report also the minimum and maximum test values.

5.2 No general figure for the precision of the results can be quoted. The range of variability of results is a particular feature of this property.

5.3 Roughness values of some papers are subject to large irreversible changes due to moisture brought about by standard conditioning and the results of this test will not necessarily indicate the roughness of the paper as manufactured.

6. TEST REPORT

6.1 The test report shall include the following particulars:

- a) reference to this Indian Standard;
- b) type of instrument used;
- c) mean result, calculated to three significant figures;
- d) number of tests;
- e) precision of the mean;
- f) coefficient of variation, as a percentage;
- g) any deviation from this Indian Standard, and details of any features that are optional; and
- h) any circumstances which might have affected the results.

INDIAN STANDARDS
ON
PAPER AND BOARD

IS:

1064-1980	Paper sizes (<i>second revision</i>)
1396-1960	Blotting paper
1763-1961	Substances of paper and pulp board
1774-1961	Paper for permanent records
1775-1961	Base paper for sensitized paper
1848-1971	Writing and printing papers (<i>first revision</i>)
2483-1963	Ticket board
2991-1964	Base paper for waxed paper
3064-1964	Hand made drawing paper
3302-1965	Backing sheet for stencil
3303-1965	Paper for match boxes
3338-1980	Sizes of correspondence envelopes (<i>first revision</i>)
3413-1977	Base paper for carbon paper (<i>first revision</i>)
3673-1966	Alkali resistant paper
4645-1968	Code of practice for storage of paper and board
4658-1968	Coated paper and board (art and chrome)
4661-1968	Glossary of terms used in paper trade and industry
4664-1968	Pulp board
5195-1969	Paper stationery items for schools
5457-1969	Sizes of folders and files
6211-1971	Code of practice for packaging of paper and board
6956-1973	Cover paper
8431-1977	Tracing paper
8460-1977	Wrapping tissue paper
9032-1978	Diazo sensitized paper
9033-1978	Reproduction tracing paper